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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

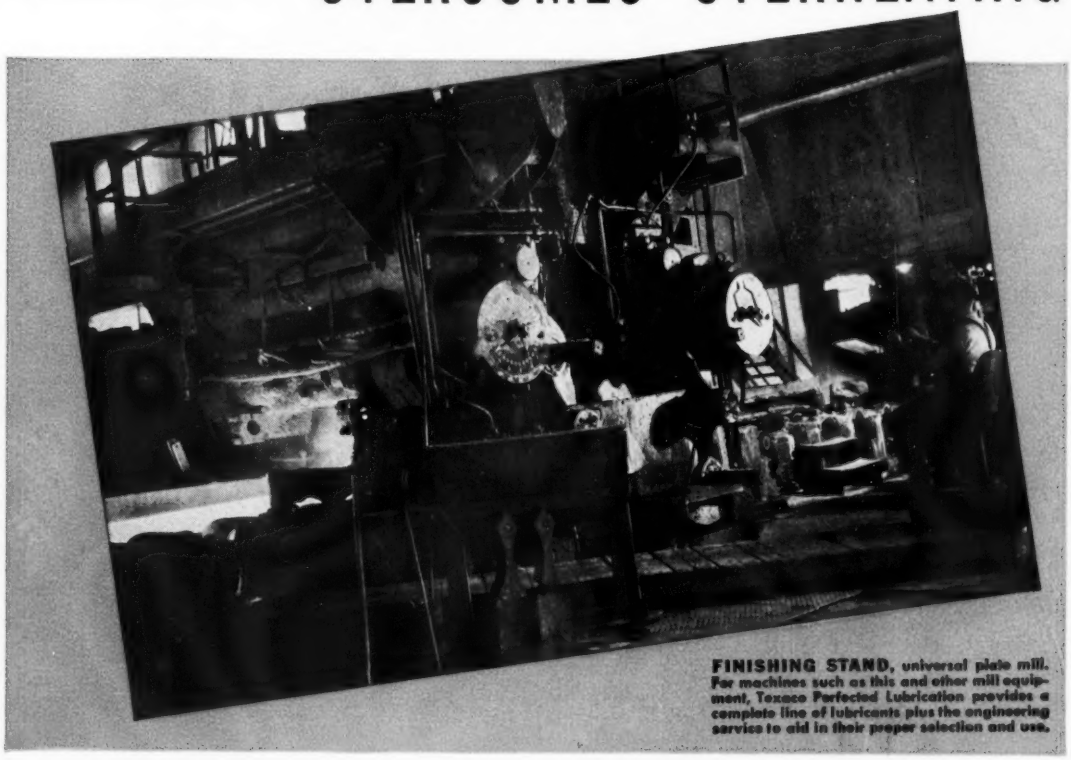
THIS ISSUE

Cooperating for Most Effective Lubrication

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

EXAMPLE OF HOW
TEXACO ENGINEERING SERVICE WORKS

STEEL MILL OVERCOMES OVERHEATING



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Cooperating for Most Effective Lubrication

VERY often lubrication is blamed for a multitude of sins which are sins of omission on the part of machinery operators, rather than sins of commission by the lubricants used. We do not wish to imply that lubricants cannot fail; they can, and very seriously, too, if not chosen wisely, or if subjected to conditions which they have not been prepared to meet. These conditions must be realized, for if most dependable lubrication is to be maintained the lubricants must possess properties which will make them most suitable for the work they must do.

So we come back to that time-honored trio: pressure, speed, and temperature. Any one or a combination of the above may present the need for specialized lubrication, by a lubricant prepared, selected and applied so as to most effectively counteract the tendency toward metal-to-metal contact.

There must be complete accord among the petroleum refiner, the machine designer, the operator and his lubricating engineer if this objective is to be attained.

DESIGN INFLUENCED BY SERVICE

The machine designer is responsible for the assembly of mechanisms which must be protected by lubrication. His consideration of lubrication must be made while the machine is in the drafting room stage. To be able to realize thoroughly the relationship of lubrication to design, it is essential for all concerned to have an intimate knowledge of the intended function of the machinery involved. This function will control the intricacy of design. Some mechanisms can be relatively simple, even tho they may be most important parts of an entire machine assembly; their lubrication becomes proportionately simple. Wherever close tolerances or careful alignments are necessary, however, the responsibility which must be borne by the lubricant becomes important. The designing engineer must realize this when planning on the means for lubricant circulation or application. Thin oil films have been widely investigated over recent years; their formation and maintenance are today assisted by the greater care observed in shop practice during manufacture, when the contact surfaces are formed and polished. The possibility of contamination is also an influence.

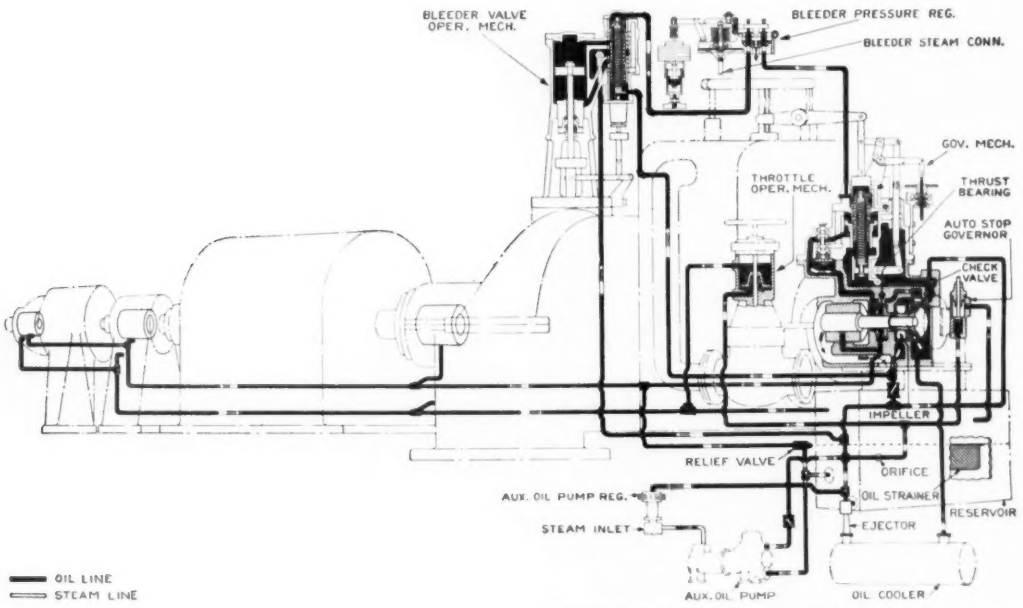
Wherever it is impossible to prevent a machine from coming in contact with abrasive foreign matter, the designing engineer may be justified in not giving it the same care as he would to a device which can be installed apart from dust or dirt, free from the detrimental effects of water, or wide temperature variations.

It is perfectly practicable, to design certain types of machinery, notably the electric motor and some varieties of machine tools, in such a dust-tight manner as to absolutely insure maintenance of quite as effective lubrication as can be secured where these conditions do not exist. This has been materially aided by the development of the anti-friction bearing and the success achieved by the builders of such

bearings in construction of dust guards, seals and means of lubricant retention.

So design oftentimes governs the degree of refinement essential in a lubricant. Wherever the design of bearings, gears, chains or other moving parts is such that the service will be comparatively rough, if it is impracticable to prevent drip or waste, a cheaper grade of lubricant can normally be recommended than where such conditions do not exist. It is true, a cheaper grade of lubricant may not possess the same quality as a more highly refined product; on the other hand, the use of the latter under such conditions would not be economical nor an assurance of any better lubrication, due to the fact that it might become unduly contaminated, with subsequent reduction in its original high quality. Furthermore, a high first cost is not justified, if the lubricant may drip or be wasted prematurely.

It is erroneous to feel, however, that where original design may be such as to lead to waste of lubricants, endeavor should not be made to overcome this, if it can be accomplished without abnormal expense. This will be especially true under conditions which may cause contamination of lubricants during operation. There are many ways by which waste can be prevented. They will depend to a large extent on the design of the equipment, the product being handled, the duty involved and the location. As an example, on certain older types of steel mill equipment gears and bearings are comparatively exposed. There is also a good deal of dirt and sometimes water around a steel plant which may come in contact with such moving parts.



Courtesy of Westinghouse Electric and Manufacturing Company

Fig. 1—Details of the oil control system for a Westinghouse condensing extraction turbo-generating unit. It is most interesting to follow the oil lines and note the location of the pumps, oil cooler, strainer, and valve controls. Likewise the governor and throttle operating mechanism.

It is often practicable, however, to enclose such gears in sheet metal housings, and to install bearing guards which will materially reduce the extent to which lubricants may be contaminated. By this prevention of contamination the durability and life of the lubricants can be extended, with assurance of better protection of the machine parts.

Where the Lubricating Engineer Fits In

The lubricating engineer must study design from this point of view. He may, however, not always be able to prevail on his principals to spend money for such means of protection. It is then his duty to decide upon grades of lubricants commensurate with the operating conditions as they may prevail.

A theoretical lubrication recommendation for any specific type of machine, however, is more or less of an ideal, for it is based upon perfected design and the assumption that the builders have realized the importance of lubrication and the necessity for protecting the moving parts as much as possible. A very high grade of grease or a filtered straight mineral oil would be adaptable to such a type of design. On the other hand, where an older

installation is involved, the engineer should use his judgment in substituting a product which from a price point of view will be in line with the existing conditions.

So a working lubrication recommendation should normally include two or more grades of lubricants of varying degree of refinement; where oils are involved, they should be of very nearly the same viscosity commensurate with the extent to which the speed and operating pressures may vary.

The operator, in turn, should realize this when in the market for such lubricants. If he is dealing with a representative of a reputable oil company, these facts will be brought to his attention, the proper viscosity or body of the lubricant decided upon, and the choice between a primary and secondary grade of lubricant justified according to the operating conditions of his installation. The routine to follow in making a primary inspection to determine these conditions, requires cooperative study of bearing clearances, alignment, how water or contaminating foreign matter is kept out, the flexibility of the lubricating equipment and the means for lubricant control.

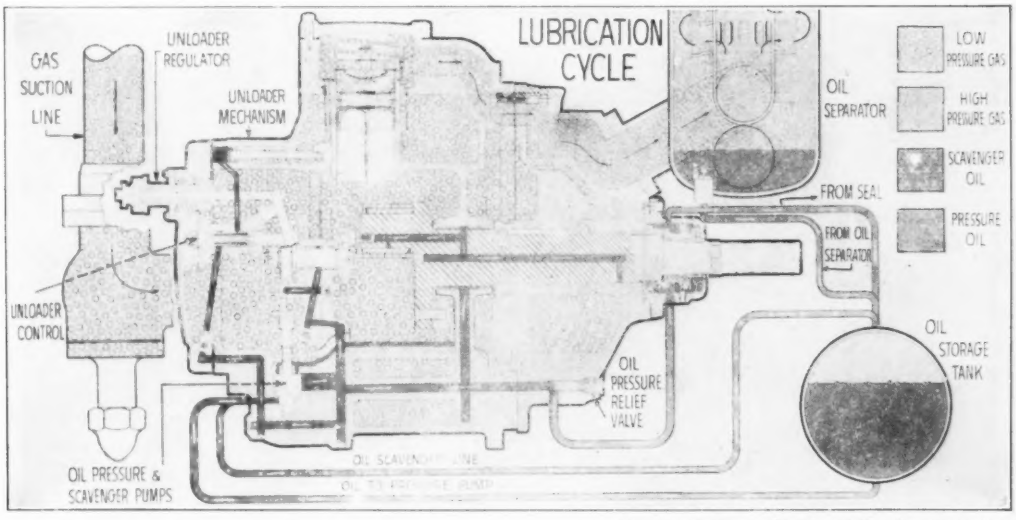
SPEED, PRESSURE AND TEMPERATURE

We have mentioned why the designing engineer should study the relation of operating conditions to machine design and ultimately successful lubrication. Now, for his benefit as well as the information of the operator and lubricating engineer, it is well to analyse the effect of speed, pressure and temperature, along with the possibility of lubricant contamination.

Speed and pressure are often related, likewise, pressure and temperature. Frequently, high speeds will be accompanied by comparatively low pressures; of equal interest is the fact that high pressures may involve higher bearing temperatures. One cannot set up empirical rules or limits to cover these conditions, however, for every machine will be more or less individual in performance.

The Effect of Speed

The body or viscosity of a lubricant can often be varied inversely with the speed. In other words, for high speed conditions, a comparatively light bodied lubricant can be used. Lower speeds will require a heavier product. All this is due to the fact that the higher the speed, the greater will be the degree to which the lubricant will be drawn into the clearance spaces by pumping action. The development of a constant film of lubricant within the bearing clearance space, however, will of course be contingent upon the extent to which automatic lubrication is maintained. Where oil is delivered by a drip feed oiler (wherein the principle is to supply just enough oil to maintain lubrication), increase in speed may result in impaired lubrication, unless the rate of drip of oil is increased. This is an important detail for the designer to remember in planning his means of lubrication and the capacity of the lubrication system.

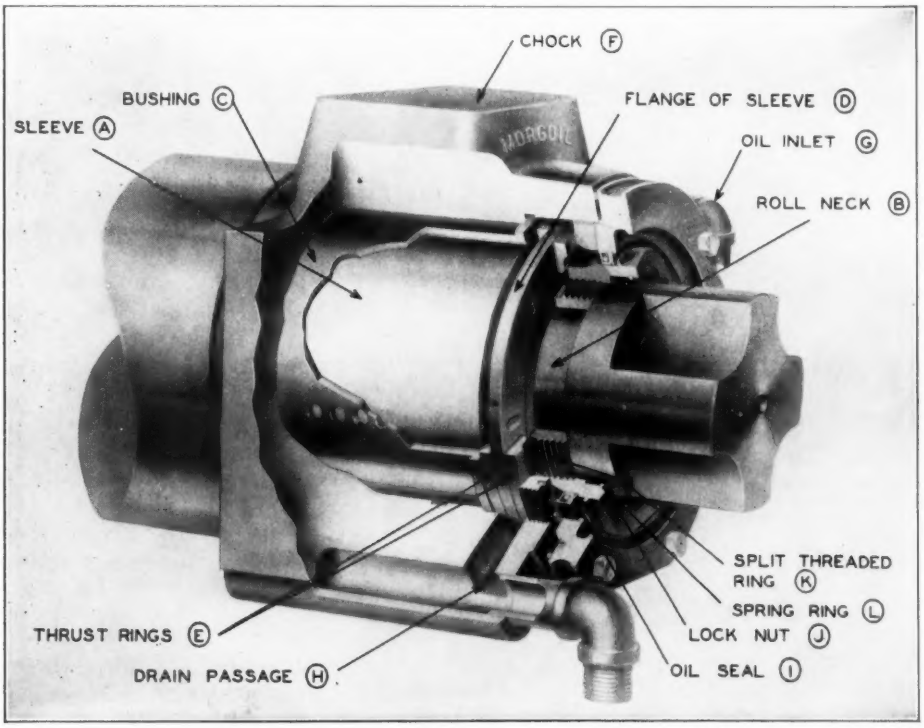


Courtesy of Airtemp Division of Chrysler Corporation

Fig. 2—Diagram showing the lubricating cycle of the Airtemp radial compressor. Note the oil pressure and scavenging pumps for complete oil circulation. These are gear driven from the main shaft. The bearings are, therefore, constantly served by oil under pressure; the rings and cylinders functioning in a mist of oil developed by oil escape from the bearings as the crankshaft rotates.

Flood Lubrication a Benefit

Force feed lubrication is more positive. Here there will always be more oil delivered than is required to maintain the desired lubricating film. Flood lubrication will also tend to bearings will remove a certain amount of the heat developed during operation, or received from any external source. This is noteworthy in connection with the operation of calender stacks in the paper industry.



Courtesy of Morgan Construction Company

Fig. 3—The Morgoil Bearing. The alloy steel Sleeve A which is ground to a mirror finish fits over and is keyed to the tapered roll neck B, and becomes the journal of the bearing. Bushing C forms the opposed bearing surface. Lubrication is maintained by oil under pressure through oil inlet G. This same oil gives flood lubrication of the thrust bearing. Oil leaves the bearing assembly via drain passage H for recirculation. The entire assembly is enclosed in a cast steel chock F. Note oil inlet G and outlet H are drilled in this chock.

materially resist the effects of pressure. This is admirably illustrated by the lubricating system of the average pressure oiled steam turbine bearing. Here, although comparatively high speeds may be involved with proportionate bearing pressures, if the oil is delivered under from eight to fifteen pounds pressure, a product of as low a viscosity as 140 seconds Saybolt at 100 degrees Fahr., will maintain lubrication adequately and insure bearing protection.

The grinding machine is another device where flooding the high speed elements has proven to be essential, and an effective aid to the development of speeds as high as 25,000 r.p.m. With both these machines, lubrication must be given most careful thought during both the designing and installation stages.

Flood lubrication possesses another advantage in that the excess oil passing through the

The Use of Grease

Wherever it is planned to use grease as a lubricant for high speed conditions, it is well to remember that such products are more particularly adaptable to anti-friction bearing construction. If the bearing is properly designed to retain the lubricant and if a high quality product is chosen, it will insure lubrication for an extensive period of operation, with the necessity for renewal perhaps only three to four times a year.

An anti-friction bearing should never be completely filled with lubricant, for this may lead to channelling of the product, failure of the seal if the grease expands, and increased power consumption, due to the drag which may be imposed upon the rolling elements. It may also lead to difficult starting in cold weather.

Gear and Chain Service

Gears, chain or cam motions require study

of speed with regard to the extent to which centrifugal force will be developed and the lubricant thrown from the moving parts. Here there is a definite relationship between speed and the adhesive characteristics of the lubricants. This will be especially true on exposed gears or chains. For this reason, the designing engineer should study the practicability of using proper housings. In an oil-tight gear or chain housing, a comparatively fluid oil can be used, especially if it is automatically delivered to the parts and not merely carried to these by dipping of the gear teeth or chain sprockets in a bath of lubricant.

Where gears and chains are not tightly housed, however, thought must be given to the adhesive characteristics as well as the viscosity of the lubricant. This is why straight mineral petroleum products are more adaptable to such installations than compounds such as greases. It is an important item which should be borne in mind, particularly by the installation engineer.

Certain types of cylinder stock greases will have comparatively high adhesive tendencies. On the other hand, they will be more expensive and not as resistant to water conditions as the straight mineral residual gear lubricants. Here again, the installation and lubrication engineers should study the conditions and make recommendations jointly, explaining to the operator the reasons for determining how heavy a product should be used, after due consideration of construction, size, the probable gear tooth pressures, the maximum speed and the manner of housing.

Pressure and Load

The designing engineer must consider bearing and gear tooth pressures from the time he makes his first layouts, due to the relation of pressure to the size of the component moving parts of any machine in service. The installation and lubricating engineers are concerned with pressure on account of the effect which it may have upon the performance of lubricants and life of bearings or gear teeth. If the viscosity or consistency of a lubricant is not sufficent to withstand any squeezing-out action which may be developed due to the construction of the moving parts, considerable damage will probably follow due to lack of proper lubrication. So pressure must be most carefully considered in the study of any lubricating problem, prior to decision as to the most effective manner of lubrication.

Pressure is both static and operating. Static pressure as developed by virtue of the dead weight or stationary load may be particularly serious, especially on bearings. The greater the operating pressures between any two contact elements, the heavier or more viscous must be the lubricating film in order to prevent metal-to-metal contact, for pressure will tend to squeeze out the lubricating film from between the wearing surfaces. In a bearing, the essential solution to this problem will be adequate bearing area and proper grooving.

Danger of impaired lubrication due to pressure can be further reduced by enclosed construction, and operating the parts in a bath or flood of lubricant. Relative to the development of such pressures, however, it must be remembered that the period of maximum intensity may be relatively brief, as for example, in the operation of a metal press.

Sometimes pressure can be met with pressure, the lubricant being maintained within the clearance spaces under the prevailing pressure of some form of pumping device. This calls for a relatively tight lubricating system throughout.

Machinery construction, manner of operation and means of application will influence the viscosity range a lubricant should possess in order to meet the probable pressure conditions. So a primary study of these conditions should always be made in order that the severity of the duty may be judged. With such knowledge as a basis and an understanding of what is actually involved when the terms "viscosity" or "body" are used, the problem of selecting either oils or greases should be materially simplified and subsequent successful operation assured.

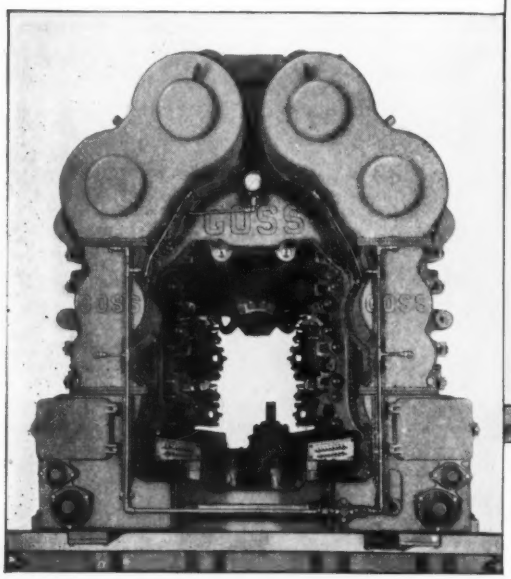
The nature of the lubricating system, the operating conditions such as speed and bearing pressures, and details of construction such as manner of grooving will usually dictate whether an oil or a grease should be used. The size, duty and bulky nature of the moving parts of the average machine involving high pressures has rendered it advisable in many cases to provide for some form of positive automatic lubrication. Greater convenience should thereby result, with frequently marked savings in labor due to reduction in the amount of attention necessary. Typical examples of this nature will be rolling equipment in the steel mill, the metal press in the automotive plant, the milling machine, the rock crusher and the textile print machine.

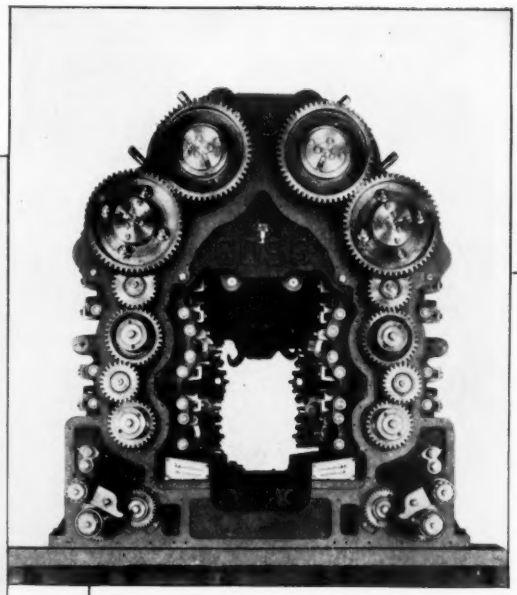
Operating Pressure

Operating pressures are developed by machinery in motion. When the rolling mill rock crusher or metal press are idling, the pressure which may exist between the teeth of their gear trains, or upon the bearings of certain of the shafting may not be abnormal. When idling there should, therefore, be no serious lubrication problem.

Courtesy of The Goss Printing Press Company

Figs. 4 and 5 (Below and Right)—The operating side of a Goss newspress equipped for automatic lubrication. Fig. 4 shows the closures and oil piping for oil circulation. Fig. 5, the gear assemblies with closures removed. The oil reservoir is located at the lower right side of the base.





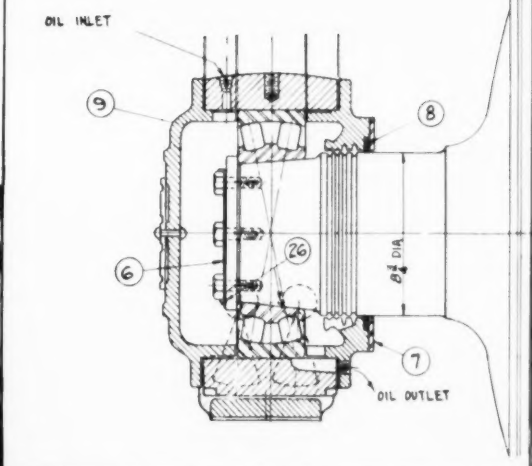


Fig. 6 (Above)—Showing the dryer bearing arrangement for a [illegible] lar interest are the provisions made for direct oil flow to obviate [illegible] retainer; 9 and 19 show the roller bearings; 22 is the dryer drum [illegible]

Courtesy of The Jeffrey Manufacturing Company

Fig. 8 (Left)—A double strand chain type of continuous bucket elevator. This is another type of materials handling equipment which is subject to heavy duty, so it requires that careful thought be given to lubrication.

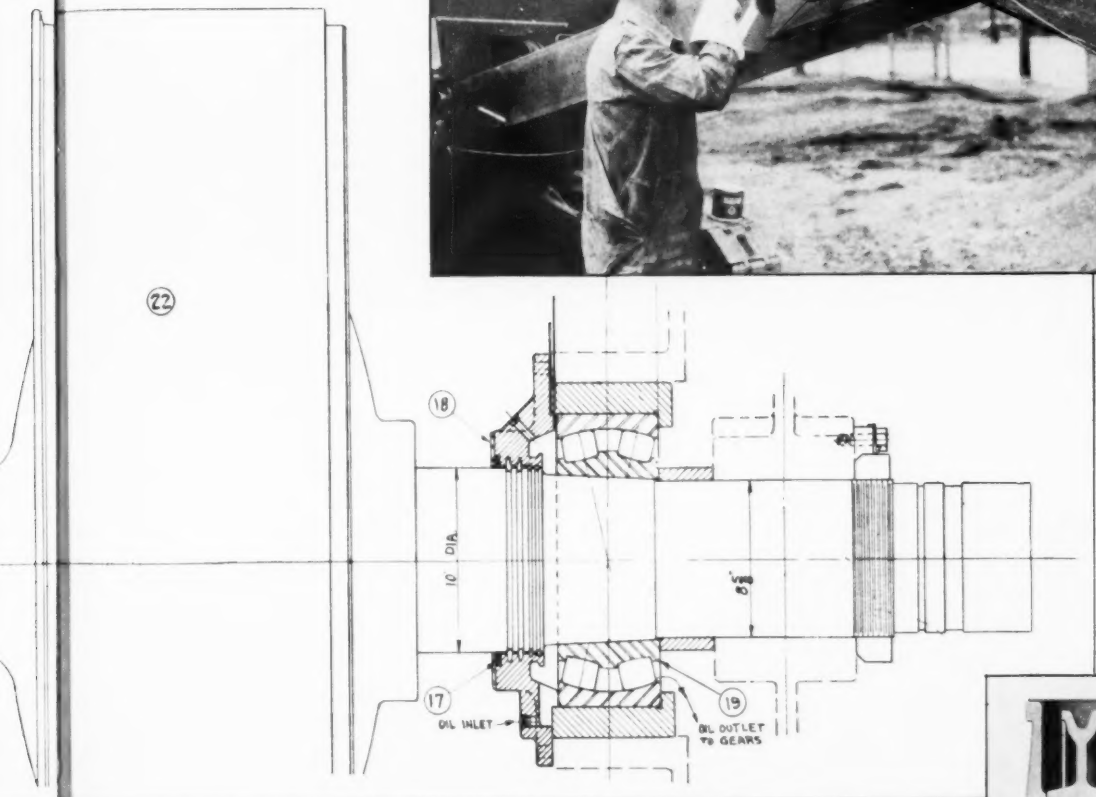
Fig. [illegible] shovel [illegible] today [illegible] handling [illegible]

Cour[illegible]

Fig. 9 (Right [illegible] conveyor roller [illegible] plication of Timk[illegible] and the labyrin[illegible] leakage, or entry [illegible] matter.

Courtesy of Bucyrus-Erie Company

Fig. 7—Grease lubricating on the boom of a power shovel [illegible] of a pressure gun. Automatic lubrication today is [illegible] the prominent features in the design of materials handling [illegible]ent.

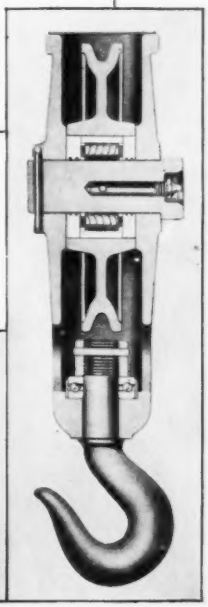


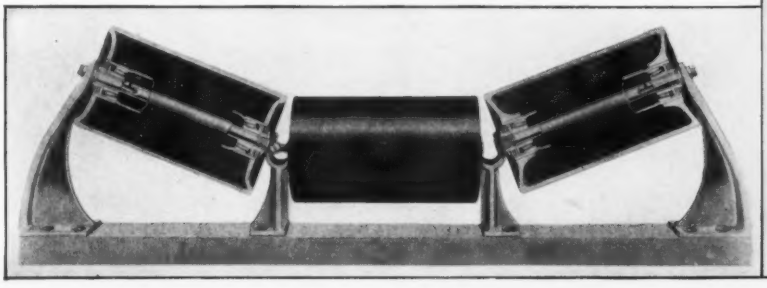
Courtesy of The Pusey and Jones Corporation

[illegible]nt for a [illegible] paper machine. Note the application of SKF spherical roller bearings on both the tending and drive side. Of particu[illegible] to obviate [illegible] which might tend to accumulate non-lubricating foreign matter. Parts 7, 8, 17 and 18 indicate retaining rings and oil [illegible]yer drum. [illegible] is a locking plate for the bearing on the tending side. Note oil inlets and outlets.

Courtesy of Shepard Niles Crane and Hoist Corporation

Fig. 10 (Right)—A Shepard Niles pulley block showing application of roller and ball bearings. Note provision for grease lubrication, and the closures for bearing protection.





Cour[illegible] Chain Belt Company

(Right[illegible]s of a chain belt [illegible] roller [illegible] showing the ap[illegible] of Tim[illegible]ed roller bearings [illegible] labyrin[illegible] seal to prevent [illegible]or entry [illegible]ubricating foreign

Under operation, however, the pressure to be exerted upon the raw materials in the formation of finished or semi-finished products may be so severe as to cause a reaction pressure back through practically all the moving elements of the machine. Not with the same intensity in every case, to be sure, for this will depend upon the size or relative importance of the parts involved. Such reactionary or back pressures, on the other hand, will be considerably in excess of the idling pressure, and hence they will be a potential cause of wear, excessive power consumption and lubricating difficulties.

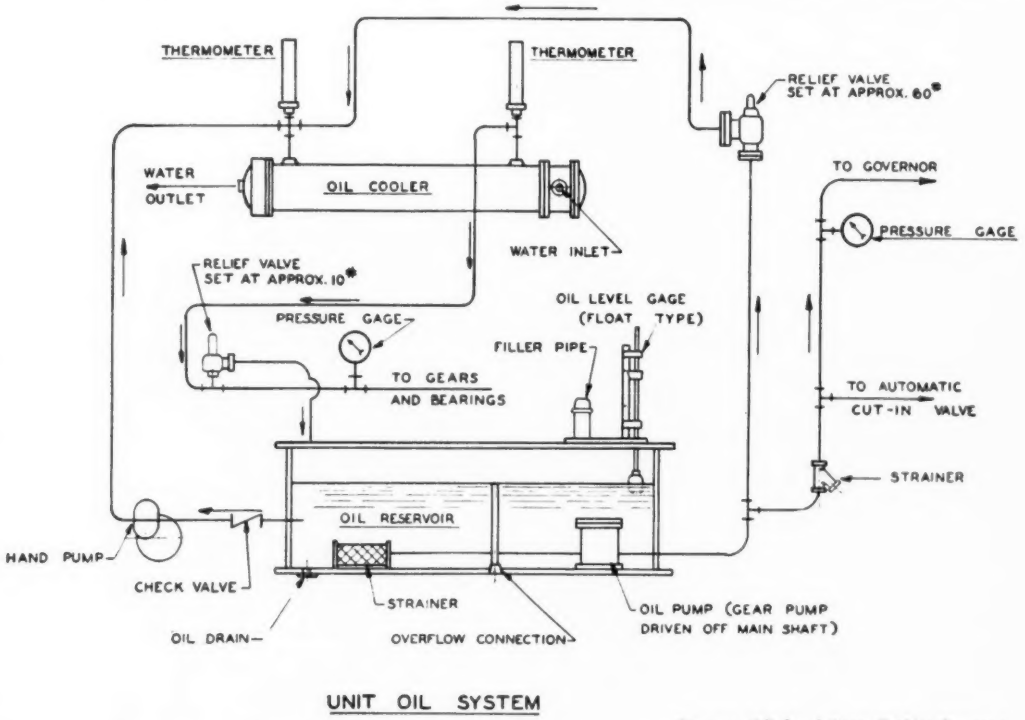
The body and adhesive ability of any lubricant for such service are most important in order that it may be able to withstand being squeezed out from between gear teeth, chain link connections, or bearings and shafting. These characteristics in the lubricants must be regarded from the viewpoint of maximum pressure involved, even though this may result in abnormal internal friction within some lubricants when certain types of machinery may be idling. It is far more important to prevent metal-to-metal contact under high operating pressures and thereby preclude the development of abnormal wear, than to reduce power consumption during idling. This is especially true, inasmuch as such machinery to develop maximum efficiency, should idle as little as possible.

Viscosity Indicates Cohesiveness

The relation which viscosity should have to the selection of lubricants for service under high operating pressures must be thoroughly understood by both the designer as well as the installation engineer. Viscosity, being a measure of the relative fluidity of a lubricant, is indicative of the body of the latter. Practically speaking, this means its ability to withstand the squeezing out effects of pressure by virtue of the cohesion between its component molecules. In a grease the viscosity of the oil content is the controlling factor, although the term "consistency" is used to indicate the body or pliability.

Certain research in regard to the relation of viscosity to pressure has dealt with pressure as applied to lubricants within a space of definite limitations. Rarely will such conditions hold true in actual operation, for it is difficult to build the lubricating system so tight in the average heavy duty machine.

Where it is practicable, however, to build a pressure lubricated bearing virtually oil-tight, one may assume that the lubricant will be subjected to mechanical pressure at a rate exceeding its tendency to leak or pass from the



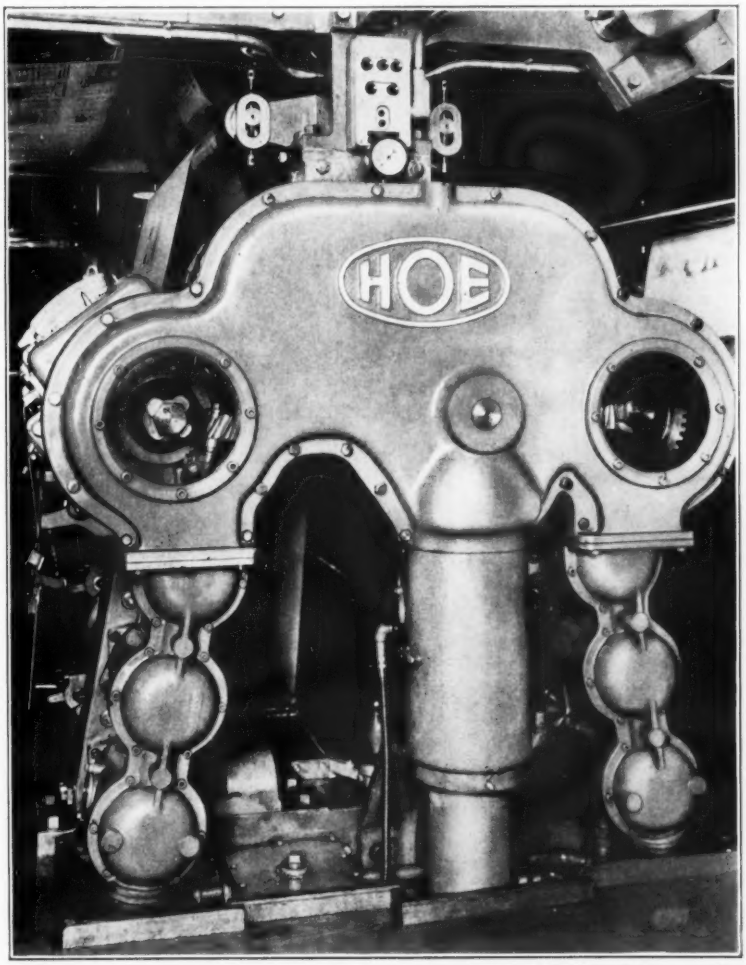
UNIT OIL SYSTEM

Courtesy of DeLaval Steam Turbine Company

Fig. 11—A DeLaval unit oil system for steam turbine service. The compact assembly of the mechanisms essential to oil circulation and cooling is especially interesting. Arrows denote the oil flow.

bearing; this assures of positive lubrication and load carrying capacity to a marked degree. Research of certain investigators has indicated that under such conditions the effects of pressure within the clearance spaces may be similar to those caused by temperature reduction at normal atmospheric pressure, the result being increase in the relative fluidity or viscosity of the oil.

Unless this occurs to an extreme, effective lubrication will be promoted for the existing oil film will be compressed and rendered more capable of preventing metal-to-metal contact.



Courtesy of R. Hoe and Company, Inc.

Fig. 12—Showing the oil tight housing on a Hoe rotary printing press. Port holes equipped with non-shatterable glass indicate the continuous flow of oil which protects the vital moving parts against wear. The oil gage mounted on the top of the unit is a reminder of lubrication worries that have been eliminated.

Lack of adequate fluidity must not result, for this would mean that certain parts of the bearing might not receive sufficient oil.

On most machinery which is subject to heavy bearing or gear tooth pressures, however, the lubricating film will have some place to go. In other words, whereas high mechanical pressure may be involved, the lubricant will still be exposed to atmospheric pressure at the ends of bearings or sides of gear teeth. In consequence, the extent to which it will continuously maintain a lubricating film of adequate thickness will depend upon its ability to resist being squeezed out, and the rate of renewal.

Temperature Affects Viscosity

Temperature will influence a lubrication recommendation wherever the operating range may be abnormal. It must be considered in deciding not only upon the means of lubrication, but also in studying the viscosity of oils or the manner of preparation of greases and the melting points of such products.

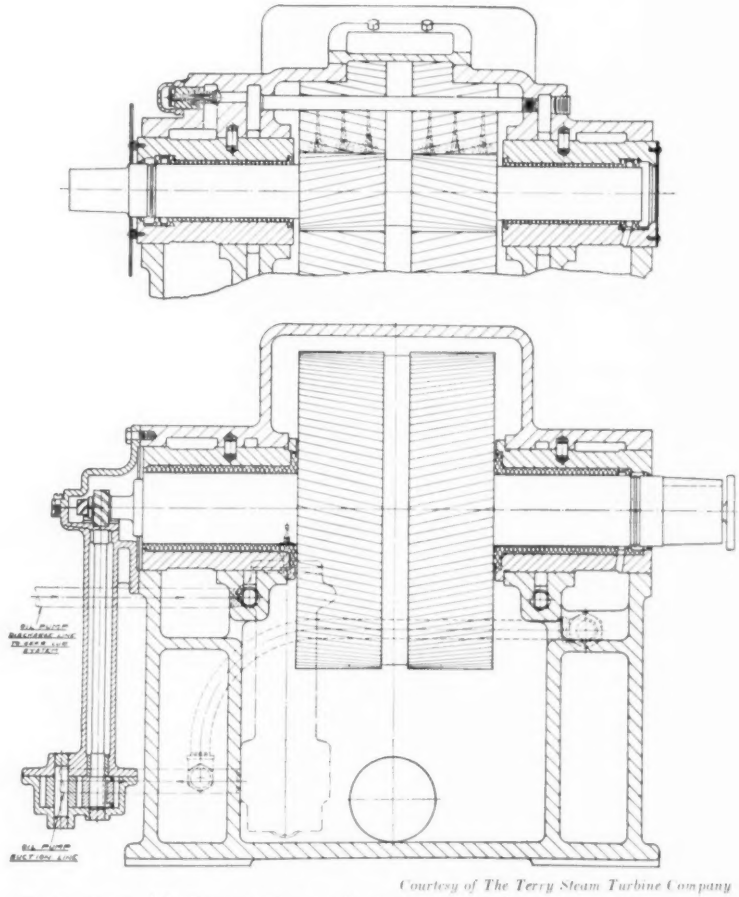
High temperature conditions will usually impose a greater duty upon a lubricant than any other phase of operation. In this connection, we must remember that the inherent possibility of development of solid friction will always be present. Solid friction between any two surfaces in motion with respect to one another implies the presence of heat, which is invariably developed by the occurrence of friction. It is the function of lubrication to eliminate solid or metallic friction, supplementing it with fluid friction.

The viscosity or body of a lubricant must be given most careful attention wherever high operating temperatures may prevail, for viscosity will vary inversely with temperature. The higher the operating temperature, the greater will be the tendency for the body or viscosity of the lubricant to be reduced. If the original viscosity is not sufficiently high to allow for this reduction, the increased fluidity may lead to impairment of the lubricating film to such an extent as to actually cause metal-to-metal contact. High pressures aggravate this condition.

The viscosity-temperature conversion chart

is helpful in formulating a lubrication recommendation for high temperature operation. By the use of such a chart, one can readily determine the operating viscosity of any lubricating oil or the oil content of a grease at the prevailing temperature of operation, knowing the viscosity at some two points such as 100 and 210 degrees Fahr. Normally lubricating oils of a viscosity up to approximately 800 seconds Saybolt at 100 degrees Fahr., are specified at this particular temperature. The viscosity of heavier lubricants, however, is usually stated at 210 degrees Fahr.

The use of an oil of suitable viscosity to meet the operating conditions will not only result in more effective lubrication, but it will also prove of decided value in reducing the amount of power required to move the working elements. In addition, any tendency towards the development of abnormal frictional heat will be reduced. All this will lead to improved lubrication, for it will enable the oil to perform its function more perfectly by virtue of its viscosity or body.



Courtesy of The Terry Steam Turbine Company

Fig. 13—Details of the Terry reduction gear showing the oil pump, the suction and discharge points, and (above) oil spray onto point of mesh of the gears. This same oil must also serve the bearings.

Relation of Viscosity in Oils

The fact that viscosity varies inversely with the temperature is an asset, for it will often enable the use of one lubricant to serve a number of points of varying external temperatures, provided the size of the wearing elements and the pressure exerted are taken into account when the lubricant is originally selected. The mistake should never be made regarding the viscosity at, say 100 degrees Fahr., as of sole importance, for an oil which might be of adequate viscosity at that temperature might be too light to meet an operating temperature range at, say, 150 degrees Fahr. In other words, we should be primarily concerned with the "operating viscosity."

It is equally as important where low temperatures are involved as when high temperatures prevail. In low temperature service, however, there will be less possibility of metal-to-metal contact between the wearing elements. Under such conditions, one must be more concerned with the occurrence of abnormal internal friction within the body of the lubricating film itself. This would, of course, lead to increased power consumption; if it becomes abnormal, it might even render the machine inoperative. There would also be difficulty in delivering such a sluggish lubricant to the moving parts on starting. Should this occur for any length of time, metal-to-metal contact might develop until the temperature of the moving parts is raised sufficiently to thin down the lubricant and cause it to flow more readily.

Lubricating oils will normally come to a so-called "equilibrium viscosity" dependent upon the temperature and pressure conditions to which they are exposed. The resultant bearing temperatures, however, may be directly affected. If, for example, the oil is too heavy in the first place, the bearing will run some-

what warmer in proportion, to reduce the oil film to the "operating" or "equilibrium" viscosity required for the specific installation.

This cannot be calculated without considerable recourse to higher mathematics. Fortunately, it is unnecessary, for experience has established certain viscosity limits for certain operating conditions which are close enough to assure of effective lubrication in accordance with the usual variations in operating conditions.

Melting Point of Greases

Melting point is often a factor where a grease is to be used. Here again the operating temperatures must be carefully considered. Certain greases will have a much lower melting point than others, due to their soap content, the nature of the soap, method of manufacture, and the nature of refinement of their oil content. Cup greases, for example, will show a melting point of around 200 degrees Fahr. Cylinder stock or soda soap products, however, can be made to show a melting point of considerably above 300 degrees Fahr., yet the penetration or consistency may be very much the same.

A cup grease should never be heated above its melting point, or even approaching same for any length of time, due to the possibility of evaporation of its normal water content and alteration of the homogeneity. This would be indicated by the separation of the oil from the soap. So it is important to study any installation wherein a fairly wide temperature range may prevail and where provisions are made for grease lubrication. Examples of this would be on the bearings of cement mill kiln trunnions, certain types of metal working machinery, some parts of the steel mill, on stoker drive operating mechanisms, and the dryer end of the paper machine.

LUBRICANT CONTAMINATION MUST BE PREVENTED

With further regard to lubricant contamination, it must be remembered that this may defeat the objective, however carefully the original selection may have been made. Contamination will be more prevalent in certain industries than in others; it will all depend upon the provisions for storage, the operating conditions to which machinery may be subjected, the nature of the materials being handled and the facility with which means of lubrication can be controlled. It all presents a varying load which lubrication must be able to assume. Let us consider steel and cement mill operations: here comparatively high temperatures will prevail in connection with much of the equipment, as for example, in steel rolling or on kiln trunnion bearings; elsewhere, as in the yard, the bearings, gearing and wire rope of cranes will be exposed to the weather; and furthermore, dust, dirt, flying scale and water may all be present, dependent upon the location and duty of the materials handling equipment.

It is a distinct problem to decide how to protect lubricants under such conditions so that they can function with satisfaction. Whenever the conditions of operation cannot be corrected, the procedure in lubricant selection and application must be planned accordingly. If properly considered, there will be assurance that high temperature and moisture conditions will be met with greater satisfaction. Viscosity, pour test or flash point, for example, will be of decided advantage in denoting how an oil will function at certain temperature extremes, and what its body will be. These characteristics cannot indicate, however, how an oil will resist contamination when exposed to foreign matter. Here, the problem will be to study storage and handling conditions, as well as the construction of wearing elements, to determine the most suitable type of guards, containers or housings, and to establish rules for handling.

Possibility of contamination in storage will largely depend upon the location of the oil house or oil room and the nature of its construction. If located adjacent to the yard hoist, or in a corner of the power plant building, where doors or windows must be left open, or where they are poorly screened, air drafts may often cause circulation of considerable abrasive dust or dirt. It will only be necessary to leave oil or grease in open containers for a short time under such conditions to result in absorption of whatever dust may settle on the surfaces. Inasmuch as virtually any type of dust is abrasive, lubricants which have been thus contaminated will very frequently tend to promote wear, by virtue of their dust content; this can materially offset reduction of wear by an oil or grease.

So it becomes advisable to store lubricants in enclosed tanks or drums, with tightly-fitting covers on all containers which have removable heads. Where oils are consumed in sufficient volume to warrant bulk storage, large permanent tanks should be installed, into which the contents of shipping drums can be emptied, or which can be filled directly from tank cars or trucks. Storage tanks of this nature are sealed to prevent leakage of oil or entry of air. They are usually equipped with measuring pumps, return drains, gage connections, and suitably covered hatches for filling or inspection. If there is further provision to draw oils only into clean distributing containers,

and in just sufficient amounts to cover immediate requirements, contamination at the point of distribution can be prevented with even better assurance.

It is easier to keep fluid oils free from contamination during storage than greases, or gear or wire rope lubricants. These heavier products will very frequently be so inert, and used in such comparatively small quantities, that storage in the shipping drums or barrels will prevail. With many metal containers, the top is so constructed as to be replaceable. As a result, it can be readily removed when a supply of lubricant is needed, and just as easily replaced to prevent the possible entry of dust or dirt. Where greases are involved, the possibility of water contamination must also be considered. Certain greases, according to their nature and the purpose for which they are intended will contain more or less water. As a general rule, this is an accurately determined quantity. As a result, should any more gain entry, there will be possibility of some greases becoming decidedly altered from both a physical and chemical nature. In others, oil separation is a very objectionable occurrence, which may be accelerated by considerable variation in storage temperature.

Handling of greases and other heavy lubricants must also be given careful consideration. In view of their consistency, they must usually be scooped from the containers. This can be done only by hand. During such a procedure, there will be considerable possibility of dirt gaining entry, especially if scoops or paddles have not been kept where they could not gather dust. Dirt may also fall off from dirty clothing.

It is virtually impossible for an operator to keep clean around certain parts of many plants, so only selected personnel should have access to lubricant storage. This is why so many plants detail a certain part of plant personnel to work only in connection with lubricants and lubrication. They, at least, can keep cleaner than many of the others; in addition, the keeping of lubrication records, and maintenance of economy in issuing the various products can be practiced. Wherever a considerable volume of lubricants is required, recording of costs of lubrication becomes a valuable item in determining production costs.

Protection against lubricant contamination in service should always be followed by the lubrication engineers department after lubricants have been issued. Very often, where gears may run exposed, or only partly enclosed, it might seem to be fruitless to insist on undue care in application of their lubricants. In many industries, the average gear is usually comparatively massive and built for rugged service. Its teeth, however, can be protected by proper lubrication, and the less contaminated the lubricants, or the more dustproof the casing, the more effectively will wear be reduced and the life of the gears prolonged.

Bearing wear will oftentimes be more serious than wear on gear teeth. Furthermore, scoring or wear in a bearing will usually develop more rapidly, for it will normally not require as much abrasive matter in the lubricating film to damage a bearing as a gear tooth. For this reason, bearings are usually constructed so that entry of dust, dirt or scale can be more effectively prevented. With sleeve bearings of the grease lubricated type, the collar of grease at the exposed ends will often serve as a very good seal. How much abrasive foreign matter may gain entry will depend upon the condition of the lubricant when applied, and the means of application.

Automatic lubrication will require renewal of lubricants at less frequent intervals than hand application. During operation any point of lubricant application should be sealed, if possible, by a suitable dust-tight cap or plug.

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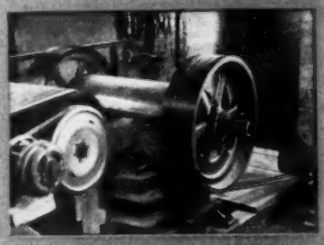

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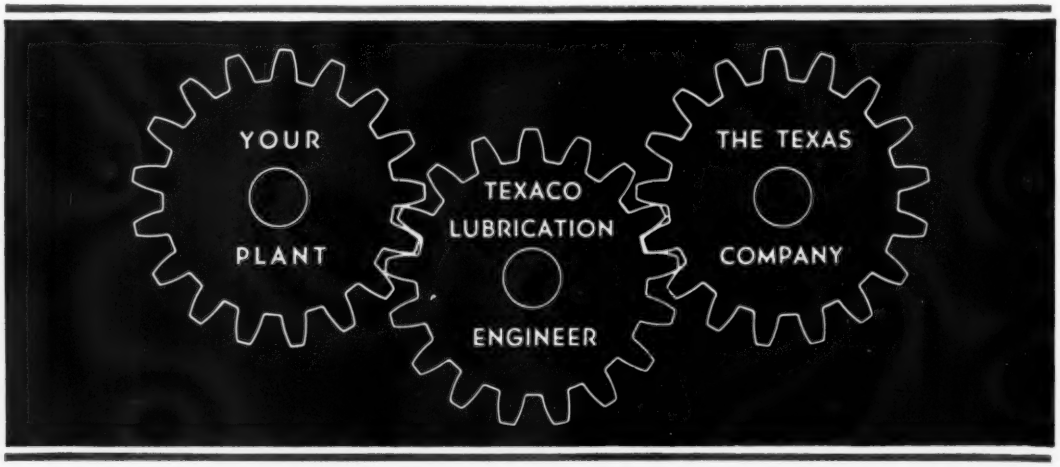

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